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STUDIES OF THE BIOLOGY AND CONTROL OF THE SPRUCE BUDWORM IN OREGON AND WASHINGTON 1953-1954

PROGRESS REPORT

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SUMMARY

Spruce budworm research studies during 1953-54 were a continuation of the long term project begun in 1951 to investigate the effects of natural control on spruce budworm populations. The studies were divided into two phases; (a) natural controls affecting high populations on unsprayed areas, and (b) natural controls affecting low populations on sprayed areas.

Studies of high populations were on three unsprayed infestations in the Blue Mts. of eastern Oregon. These were the Chesnimnus and North Powder areas where studies have been continued since 1951 and the Ochoco area where studies were begun in 1953. Studies of low populations on sprayed infestations were in eight areas -- four in the Cascade Mts. and four in the Blue Mts.

On unsprayed areas the findings were as follows:

1. On the Chasnimnus area, egg and immature larva populations showed annual fluctuations. These fluctuations seem to be the normal pattern for this area. Similar annual fluctuations were noted in the effectiveness of parasites and groups of parasites. However, the aggregate parasitisms for 1953 and 1954 were approximately equal.

2. On the North Powder study plot the population trend was generally upward, a trend which continued until the plot was sprayed in 1955. This population trend existed in spite of comparatively high aggregate parasitisms -- 55 percent in 1953 and 59 percent in 1954.

3. The population data recorded for the Ochoco study area showed a strong upward trend. Populations in the early stages of development in 1954 were approximately double those of 1953. Data on parasitism showed an equally strong downward trend. This trend in parasitism was reflected in a much higher egg population for the 1955 brood.

4. The most important parasite species encountered in 1953-54 on unsprayed areas were Apanteles fumiferanae and Glypta fumiferanae. Other species of frequent importance were Omotoma fumiferanae, Phytodietus fumiferanae, and Phaeogenes hariolus.

5. Natural control factors affecting over-wintering populations caused population reductions of 79 and 96 percent on two of the study areas. These reductions were recorded from measurements of egg populations in the fall and surviving larva populations the following spring.

On sprayed areas the findings were as follows:

1. Population trends in 1951-52 were mainly reversed in 1953-54. However, the populations on all plots were very low. Therefore, only a small number of budworm were recovered and the apparent changes in population may have been due to sampling error.

2. The parasites attacking the immature larvae on these sprayed plots continued to effect significant natural control.

REVIEW OF PREVIOUS WORK

The first spruce budworm research in Oregon and Washington was in 1948. This was primarily an experiment in control by aerial spraying but preliminary biological studies were also begun. In 1949 and 1950 these control experiments and preliminary studies were continued. In 1951 intensive biological studies were undertaken for the first time and the work reported here for 1953-54 is a continuation of those studies.

The experiments in spruce budworm aerial spraying achieved a practical control method which has successfully controlled budworm infestations in Oregon and Washington since 1949 (Eaton et. al., 1949) (Whiteside, 1956). The preliminary biological studies of 1949 and 1950 provided basic information which improved the methods of control and the methods of population survey. The findings from these studies have been summarized in previous reports (Carolin, 1950) (Lindsten and Wright, 1951).

The intensive studies begun in 1951 were designed to obtain further information on the biology of the budworm in Oregon and Washington. This information is needed to improve control methods and prevent future damage by this pest. In brief summary, the studies in 1951 and 1952 showed no significant changes in natural control by parasites on unsprayed areas. On sprayed areas the budworm population remained low, and the parasites of the early instar larvae continued to cause significant natural control. The results of these studies have been summarized by Carolin and Wright (1953), and Coulter (1953).

STUDIES ON UNSPRAYED AREAS

The studies in 1953-54 on unsprayed areas were undertaken to provide information on the natural control of spruce budworm epidemics. The primary objectives of these studies were to estimate:

1. The budworm population and population trends.

2. The natural control of budworm populations by parasites and the trend in budworm parasitism.

3. The amount of budworm mortality between egg deposition and attack of buds.

Three study plots in unsprayed areas of infestation were used in 1953-54. These included the two existing permanent study plots at Chesnimnus and North Powder established in 1951, and a new study plot in the Ochoco infestation. Studies at Waterman Flat were discontinued when this area was sprayed in 1952.

The study plan was a continuation of the plan initiated in 1951 and followed in 1952 (Coulter, 1953a). Population data were recorded for two life stages of the budworm; the egg and immature larva. Parasitism data were recorded for four life stages; the egg, immature larva, mature larva, and pupa. The surveys and collections of budworm host material were timed for optimum parasitism. Degree of parasitism was determined by the following methods: examination of egg masses, dissection of immature larvae, and rearing of mature larvae and pupae. Identification of parasite species was supplied by the Insect Identification and Parasite Introduction Laboratory, U. S. Agricultural Research Service.

Evaluation of mortalities in the overwintering populations was made at the Ochoco and Chesnimnus study plots. Comparisons of populations were made by sampling the number of eggs laid in the fall and the number of larvae subsequently mining the buds and needles the following spring.

Status of Budworm Populations

Estimates of budworm populations were obtained for two stages of development in each generation. The population data for these stages during 1951 through 1954 are summarized in Table 1 to show the population trends on the three study areas.

Chesnimnus - The egg and immature larva populations were two to three times greater for the 1953 brood at Chesnimnus than for the 1952 brood. However, in 1954 the population decreased considerably. The number of eggs for the 1954 brood was less and the immature larvae population was about one-third of that found in 1953. The number of eggs producing hibernating larvae for the 1955 generation again increased. These relatively large fluctuations in population appear to be normal for the Chesnimnus infestation. They have been noted in previous population surveys (Coulter, 1953) and are also evident from aerial survey records of defoliation. No prediction of population trend in this area can be given.

North Powder - A general upward trend in the population on the North Powder area began in 1952 when the immature larva population increased to twice that found in 1951. In 1953 the larva population increased again even though fewer eggs were recorded. In 1954 both egg and larva populations were greatly increased. Finally, the number of eggs producing larvae for the 1955 infestation were nearly double the number responsible for the 1954 infestation. This trend in population and the potential damage it represented was taken into consideration in determining the need for control in this area. It was sprayed in 1955.

Ochoco - In 1953, when studies were begun in this area, the population was light to moderate. The 1954 population showed a strong upward trend with an increase of one-third in the egg population and more than double the immature larval population. This trend continued when the egg population recorded for the 1955 infestation was three times the 1954 egg population. This population trend influenced the decision to spray the Ochoco infestation in 1955.

Status of Budworm Parasitism

Parasitism was determined for four life stages of the budworm. The total parasitism for each of these stages, and the aggregate parasitism by species is tabulated in Table 3. All annual records to date for each area are included to show trends in parasitism by species of parasite.

Chesnimnus - Overall parasitism remained relatively constant in 1953-54 on the Chesnimnus study area. However, there were fluctuations in parasitism by species and groups of species attacking different stages of development.

Parasitism of eggs increased from 5 percent for the 1952 brood to 8 percent in 1953. It then dropped to 2 percent in 1954. The 8 percent parasitism for the 1953 brood was the highest egg parasitism recorded to date in the Northwest. All egg parasitism was by the chalcid, Trichogramma minutum.

Parasitism of immature larvae was not recorded for 1953 but in 1954 was 31 percent. This is equal to the parasitism of this stage in 1952. However, in 1954 Apanteles fumiferanae caused almost one-third more parasitism than Glypta fumiferanae. This is a reversal of the results in 1951 and 1952 when parasitism by Glypta was much higher than the parasitism by Apanteles.

Parasitism of mature larvae on the Chesnimnus plot was relatively constant for the two-year period of 1953-54, but was nearly twice that recorded for the preceding period of 1951-52. This increase was mainly due to an increase in parasitism by two common species, Omotoma fumiferanae and Madremyia saundersii. Only parasitism by Phytodietus fumiferanae remained approximately constant for the four years. Parasitism by two other species was recorded on this study plot for the first time; Phorocera incrassata in 1953 and Ceromasia auricaudata in 1954.

Parasitism of pupae was variable in 1953 and 1954. The combined parasitism for 1953 was relatively low -- 4 percent. All common species were present but ineffective. Even Phaeogenes hariolus, which caused 10 percent parasitism on this study plot in 1952, caused only 1 percent parasitism in 1953. In 1954 the combined parasitism was 10 percent. All common species were again present, but only Agria affinis was present in significant numbers, causing 6 percent parasitism.

Summary of the parasitism and importance of parasite species at Chesnimnus shows aggregate parasitism relatively high in 1953-54. Apanteles fumiferanae, Glypta fumiferanae, and Omotoma fumiferanae are the most important species to occur on this study plot to date. Other parasite species have been important at times. These include Phaeogenes hariolus in 1952, Trichogramma minutum attacking the 1953 generation, and Agria affinis in 1954.

North Powder - In 1953-54, the parasitism at the North Powder study plot was comparatively high. The aggregate parasitism in both years was nearly twice that recorded for 1952. A few species of common parasites were mainly responsible. However, similar to the situation at the Chesnimnus plot, there were seasonal fluctuations in parasitism by species and groups of species.

Egg parasitism continued very low in 1953-54. However, data for 1953 are not significant, since only 2 egg masses were found. But in 1954, a total of 159 egg masses were recorded of which only one was attacked by Trichogramma minutum.

Increased parasitism of immature larvae was partly responsible for the relatively high aggregate parasitism at the North Powder plot in 1953-54. Apanteles fumiferanae continued to be the most important parasite in this study area and was twice as effective during this study period as in 1951-52. Glypta fumiferanae continued as the second most important parasite, and it, too, was twice as effective as in 1951-52.

Increased parasitism of mature larvae was the other factor responsible for the high aggregate parasitism in 1953 and 1954. Omotoma fumiferanae, which has been the most important parasite in this group, was about twice as effective in 1953-54 as in 1951-52. Other parasites in this group were variable in their effectiveness. Parasitism by Ceromasia auricaudata increased for one year in 1953 and Phytodietus fumiferanae for one year in 1954.

Parasitism of pupae was about average in 1953-54, without the large increases recorded for parasitism of larvae. However, there were fluctuations between the years and within the species. The combined parasitism for 1954 was 13 percent which was an increase over the parasitism in the previous years. This increase was due to a relatively large number of Phaeogenes hariolus. The other common species of pupal parasites were of average effectiveness or less. It is interesting to note that Ephialtes ontario has not been recorded from the North Powder study area. It was present each year at Chesnimnus from 1951 to 1954 and at the Ochoco study plot in 1953.

Summary of the parasitism on the North Powder plot shows a relatively high aggregate parasitism for 1953 and 1954. The parasite species of Apanteles fumiferanae, Glypta fumiferanae, and Omotoma fumiferanae are the most important to occur here. Other species which have been important at times are Horogenes sp. in 1951, Phaeogenes hariolus in 1952 and 1954, Itoplectis 4-cingulatus in 1952, Ceromasia auricaudata in 1953, and Phytodietus fumiferanae in 1954.

Ochoco - The parasitism on the Ochoco study plot was high in 1953 and low in 1954. In addition to annual variation there were also fluctuations in parasitism by certain species, particularly those attacking mature budworm larvae.

Egg parasitism was slightly low for the two year period. The 3 percent parasitism of the 1953 brood by Trichogramma minutum is near the general average for this parasite. This dropped to 1 percent for 1954.

The parasitism of immature larvae on the Ochoco study plot in 1953 established a new high for these study areas. Glypta fumiferanae was 29 percent and Apanteles fumiferanae was 23 percent. The high parasitism by these two species was primarily responsible for the high aggregate parasitism here in 1953. Both species were nearly twice as effective in 1953 as in 1954. It should be noted that Glypta fumiferanae was more effective than Apanteles fumiferanae both in 1953 and 1954.

Parasitism of mature larvae was slightly higher in 1953 than in 1954, but was comparatively low in both years. Phytodietus fumiferanae was the most important parasite in 1953, with Madremyia saundersii second in importance. In 1954 Omotoma fumiferanae was first in importance with Aplomya caesar second. These were the first records of the latter species on these study plots.

Parasitism of pupae was low during both years. Itoplectis 4-cingulatus was the most important species. Phaeogenes hariolus, the most common species on the other study plots, was very low in 1953 and not even recorded in 1954.

Summary of the parasitism on the Ochoco study plot during 1953-54 shows a trend of decreasing parasitism. A large decrease in the effectiveness of the parasites of immature larvae, Apanteles fumiferanae and Glypta fumiferanae, was the primary cause of this trend. These two species were by far the most important parasites found on this study plot. Other species of importance were Madremyia saundersii in 1953, Phytodietus fumiferanae in 1953, and Omotoma fumiferanae in 1954.

Presence of Less Common Parasites

Mature larvae and pupae were mass-collected in 1954 from each study plot to obtain additional records on parasite occurrence. Some species of parasites had been consistently recorded from one area but not from another. The mass collections were made in an attempt to determine if these species were generally present in all areas but in very small numbers which by chance had not been recorded in the regular sample. A total of seven species were recorded which had not been recorded on these areas previously. These were as follows:

Chesnimnus	-	Eubadizon gracile[1/]
North Powder	-	Phryxe pecosensis, Phorocera erecta
Ochoco	-	Phorocera incrassata, Madremyia saundersii, Nemorilla floralis, Agria affinis

It is assumed that these species are generally present in all three study areas. The status of other, less common species, is not known.

Natural Control Factors other than Parasites

In 1953 an assessment was made of total population reduction during the hibernating stages of the spruce budworm. In 1952 it had become increasingly apparent that some natural control factor other than parasitism was causing considerable mortality. Aggregate parasitism was far short of the aggregate mortality of 98.5 percent, which is required to hold this insect's population static, yet the populations were decreasing or only increasing slightly. Since no other factor capable of causing high budworm mortality had been observed during field studies, some factor or factors were affecting a period of development not studied. One of these periods is the developmental period between egg hatch in the late summer and active larval feeding in the spring.

1/ From an extra collection for mature larvae in 1952.

Population data were available on the number of larvae going into hibernation from the egg surveys made in the fall of 1952. In 1953, after all larvae had broken hibernation, special surveys were made on the Chesnimnus and Ochoco plots to assess the surviving populations feeding in the needles and buds.

Comparison of the fall and spring surveys showed a population reduction of 79 percent on the Chesnimnus study plot trees and 96 percent on the trees at the Ochoco study plot. These data cannot be considered an absolute sample of population reduction, since the young larvae are dispersed following hatching from the eggs and again following the end of hibernation. Some of the larvae drift to the understory and become established on reproduction and represent an error in the reduction percentages. However, the sample was taken from or near mid-crown so that drift-off of the sample branches was at least partially compensated by drift-on.

STUDIES ON SPRAYED AREAS

Studies in 1953-54 on sprayed areas were mainly to determine the status of the budworm and its natural control factors on areas where high populations had been successfully controlled. The areas studied were sprayed in 1949 and 1950. Earlier studies in these areas had shown no significant increase in budworm populations during the years immediately following spraying.1/ They also showed that most of major parasites of the budworm survived the spraying. The specific objectives for the studies in 1953-54 were as follows:

1. To record the trend of budworm populations on areas sprayed in 1949 and 1950.

2. To investigate the relative effectiveness of one of the major parasite groups attacking the low level populations remaining on these areas.

The study procedure followed the methods used in 1951-52. Twenty plots representing eight sprayed areas were resurveyed. Foliage samples were obtained at each plot when the majority of the young larvae had left the needle-mining stage and were attacking the newly opened vegetative buds. The sample was a total of not less than ten 15-inch twigs from a total of three trees at each of ten subplots, making a total sample of 100 twigs per plot. All larvae were dissected to determine the degree of parasitism.

1/ Excepting the reinfestation at Beaver Butte and Bear Springs on the Mt. Hood area where control was applied too late in the developmental period (Coulter, 1953).

Status of Budworm Populations

No serious reinfestation was recorded in 1953-54 on the eight sprayed study areas. However, four years of population data had been accumulated which showed the trends in the low-level residual populations (table 4).

Upward trends were recorded on the Eugene and South Umatilla areas. On the Eugene area in 1951-52 the populations had been very low. In 1953 a significant increase occurred and in 1954 a greater increase occurred. On the South Umatilla area the population had decreased from 1951 to 1952 but showed a gradual increase during 1953-54.

Downward trends were recorded on the Mt. Hood, McKenzie, Walla Walla, Catherine Creek and Tollgate areas. The epidemic population at the Beaver Creek and Bear Springs plots on the Mt. Hood study area was resprayed in 1952 and continued very low in 1953-54. The upward trend in population on the McKenzie and Walla Walla areas in 1951-52 declined suddenly in 1953-54. The comparatively high residual population on the Catherine Creek area in 1951 and 1952 declined slowly in 1953 and 1954. The low population on the Tollgate area dropped even lower when no budworm were recorded on the 1953 or 1954 surveys.

The very low population on the Roseburg area in 1952 continued in 1953 and 1954. The population in this area has remained low since it was sprayed in 1950.

Status of Parasites

Parasitism was determined for one stage of budworm development - the immature larval stage. Even at this early stage of development the number of hosts obtained was so small that reliable estimates of parasitism were obtained for only one study area each year. However, a rough estimate of trend in parasitism was obtained by grouping all twenty plots into two classes - Cascade Mts. and Blue Mts. (table 5).

Cascade Mts. In 1953 the parasitism at the Eugene area, representing the Cascade Mts., was very low at 10 percent. This parasitism was due entirely to Glypta fumiferanae and Horogenes sp. There is no explanation for the absence of Apanteles fumiferanae which is normally one of the most effective parasites of the spruce budworm in Oregon and Washington. In 1954 the parasitism was higher at 15 percent, but again Apanteles was relatively ineffective, causing less parasitism than Horogenes (tables 7 & 8).

Blue Mts. In 1953 the 42 percent parasitism in the Blue Mts. was recorded mainly from three study plots in the Catherine Creek area. Apanteles, Glypta, and Horogenes were all present and ranked in effectiveness in the order mentioned. In 1954 the parasitism decreased to 24 percent (tables 7 & 8). However, this parasitism was higher than that recorded on the Cascade Mts. plots in 1954. Table 5 shows that the annual parasitism of this stage of development has been consistently higher on the Blue Mts. plots than on the Cascade Mts. plots.

From the studies on sprayed areas in 1953-54 (four and five years after spraying) it can be concluded:

1. Budworm populations have remained generally low on all areas where good control was obtained.

2. Parasitism of the immature larval stage of development, although decreasing in the Cascade Mts. areas, continued as an important factor of natural control.

STATUS OF STUDIES

Further study of the natural controls affecting the budworm are needed to improve control methods and prevent damage. Expansion of the studies on high populations is needed to investigate all factors of natural control. More intensive studies are needed on sprayed areas to investigate the long term effects of spraying; particularly on areas where biological data were recorded before spraying. Plans are to continue the studies on unsprayed and sprayed areas, and to expand these studies when additional personnel become available.

REFERENCES CITED

Buchanan, W. D.
1949. Spruce budworm report. (Special report). U.S. Bur. Ent. and Plant Quar. Forest Insect Lab., Fort Collins, Colo. 4 pp. (Processed).

Carolin, V. M.
1950. Studies of the biological control of the spruce budworm in Oregon. Special report. U.S. Bur. Ent. and Plant Quar. Forest Insect Lab., New Haven, Conn. 25 pp. (Processed).

_____ and Wright, K. H.
1953. Studies of the biology and control of the spruce budworm in Oregon and Washington. Special report. P 2 (1951). U.S. Bur. Ent. and Plant Quar. Forest Insect Lab., Portland, Ore. 30 pp. illus. (Processed).

Coulter, W. K.
1953. Studies of the biology and control of the spruce budworm in Oregon and Washington. Special report. P 3 (1952). U.S. Bur. Ent. and Plant Quar. Forest Insect Lab., Portland, Ore. 17 pp. (Processed).

_____
1953 a. Work plan for the study of biological factors in the control of the spruce budworm in Oregon and Washington, season of 1953. U.S. Bur. Ent. and Plant Quar. Forest Insect Lab., Portland, Ore. 8 pp. (Processed).

Eaton, C. F., Beal, J. A., Furniss, R. L., and Speers, C. F.
1949. Airplane and helicopter spraying with DDT for spruce budworm control. Jour. Forestry 47:823-827.

Lindsten, A. and Wright, K. H.
1951. The 1949 western Oregon spruce budworm control project. (Special report). Oreg. State Bd. Forestry and U.S. Bur. Ent. and Plant Quar. Forest Insect Lab., Portland, Ore. 71 pp., illus. (Processed).

Whiteside, J. M.
1956. Spruce budworm control in Oregon and Washington, 1949-1956. U.S. Forest Serv. Pacific Northwest Forest Expt. Sta., Misc. Paper, 23 pp. illus. (Processed) and Proc. Tenth Internatl. Cong. Ent. 4:291-302, (1958).

A P P E N D I X

Primary Parasites Recovered from the
Spruce Budworm in Oregon, 1953-54

HYMENOPTERA

Braconidae

Apanteles fumiferanae Vier.
Eubadizon gracile Prov.
Meteorus trachynotus Vier.

Ichneumonidae

Ephialtes ontario (Cress.)
Glypta fumiferanae (Vier.)
Horogenes species
Ischnus inquisitorius atriceps (Cress.)
Itoplectis 4-cingulatus Prov.
Phaeogenes hariolus (Cress.)
Phytodietus fumiferanae Rohw.

Trichogrammatidae

Trichogramma minutum Riley

DIPTERA

Larvaevoridae

Actia interrupta Curr.
Aplomya caesar (Ald.)
Ceromasia auricaudata T.T.
Madremyia saundersii Will.
Nemorilla floralis Fall.
Omotoma fumiferanae (Toth.)
Phorocera incrassata Smith
Phorocera erecta Cog.
Phryxe pecosensis T.T.

Sarcophagidae

Agria affinis Fall.

Table 1.--Estimates of spruce budworm populations on three unsprayed areas in eastern Oregon, 1951-54

Study area and Year	Defoliation 1/	Egg masses 2/			Immature larvae		
		Number of samples	Number of egg masses	Masses per sample	Number of samples	Number of larvae	Larvae per sample
		--- Branches ---			--- 15-inch twigs ---		
Chesnimnus							
1951	Light	10	16	1.6	180	612	3.4
1952	Moderate	20	81	4.1	142	471	3.3
1953	Heavy	20	270	13.5	158	1330	8.4
1954	Light	50	488	9.8	100	248	2.5
1955	-	20	242	12.1			
North Powder							
1951	Light	-	-	-	150	112	0.7
1952	Light	20	18	0.9	100	143	1.4
1953	Light-moderate	20	2	0.1	100	286	2.9
1954	Heavy	50	159	3.2	90	413	4.6
1955	-	20	118	5.9			
Ochoco							
1953	Light	49	287	5.9	100	377	3.8
1954	Moderate	50	401	8.0	100	841	8.4
1955	-	20	475	23.8			

1/ Defoliation is based on aerial reconnaissance survey observations where "light" is defoliation barely visible from the air, "moderate" is top one-fourth of the visible crown defoliated; "heavy" is the top one-half of visible crown defoliated; and "very heavy" is the visible crown completely defoliated.

2/ Egg mass data are tabulated for the year in which the brood feed.

Table 2.--Parasitism of the spruce budworm on three unsprayed areas in eastern Oregon, 1951-54

Study area and year	Life stages attacked: Eggs [1]	IV Stage larvae	V Stage larvae	Mature larvae	Pupae	Aggregate [2]
	Percent					
Chesnimnus						
1951	2.7	0.7	25.8	7.6	7.0	38.3
1952	5.0	-	30.0	10.6	13.0	48.2
1953	8.1	0.5	- [3]	21.6	3.6	31.0 [3]
1954	2.2	-	30.9	23.7	10.0	51.6
North Powder						
1951	-	4.5	23.7	9.8	2.7	36.0
1952	0	-	21.4	4.8	8.1	31.3
1953	0	-	37.1	23.2	7.0	55.1
1954	0.6	-	43.4	16.0	13.1	58.9
Ochoco						
1953	2.7	0	52.1	7.9	2.6	58.2
1954	1.0	-	29.5	5.5	2.3	35.5

1/ Egg parasitism data are based on whole egg masses and are tabulated for the year in which the brood feed.

2/ The aggregrate parasitism is a + (1-a) b + (1-a)(1-b) c ------etc., where a, b, c, etc., are the combined control factors affecting a stage of development.

3/ No data obtained in 1953 on parasitism of V stage immature larvae at Chesnimnus study plot. A more accurate estimated aggregrate parasitism of 52 percent is obtained by substituting a mean combined parasitism of 30 percent for this stage.

Table 3.--Parasitism of the spruce budworm by species of parasites on three unsprayed areas in eastern Oregon, 1951-54

Stage of host killed and parasites attacking during these stages	Chesnimnus								North Powder								Ochoco			
	1951		1952		1953		1954		1951		1952		1953		1954		1953		1954	
	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism	Number sampled	Parasitism
		Percent		Percent		Percent		Percent		Percent		Percent		Percent		Percent		Percent		Percent
Egg 1/	16		81		270		488		-		18		2		159		287		401	
Trichogramma minutum		2.7		5.0		8.1		2.2		-		0		0		0.6		2.7		1.0
Immature larvae - IV stage	300		-		2283		-		112		-		-		-		95		-	
Unknown		0.7		-		0.5		-		4.5		-		-		-		0		-
Immature larvae - V stage	233		100		-		97		173		84		70		83		94		105	
Apanteles fumiferanae		9.4		10.0		-		17.5		11.6		13.1		21.4		25.3		23.4		12.4
Glypta fumiferanae		13.7		19.0		-		12.4		8.7		7.1		15.7		15.7		28.7		16.2
Horogenes species		2.6		1.0		-		1.0		3.5		1.2		0		2.4		0		1.0
Combined parasitism		25.8		30.0		-		30.9		23.7		21.4		37.1		43.4		52.1		29.5
Mature larvae	250		188		250		236		102		186		138		237		242		236	
Omotoma fumiferanae		6.0		9.0		15.2		14.0		6.9		3.2		11.6		8.4		0.8		3.4
Ceromasia auricaudata		0		0		0		2.1		2.0		0.5		6.5		1.3		0		0.4
Madremyia saundersii		0		0.5		1.6		2.1		0		0.5		2.2		1.7		2.9		0
Phorocera incrassata		0		0		2.8		3.0		0		0		0.7		0.4		0		0
Aplomya caesar		0		0		0		0		0		0		0		0		0		1.3
Actia interrupta		0		0		0		0.8		0		0		0		0		0		0
Phryxe pecosensis		0		0		0		1.3		0		0		0		0		0		0
Phytodietus fumiferanae		1.2		0.5		1.6		0.4		1.0		0.5		2.2		4.2		4.1		0.4
Meteorus trachynotus		0		0.5		0		0		0		0		0		0		0		0
Agria affinis		0		0		0.4		0		0		0		0		0		0		0
Unknown		0.4		0		0		0		0		0		0		0		0		0
Combined parasitism		7.6		10.6		21.6		23.7		9.8		4.8		23.2		16.0		7.9		5.5
Pupae	229		368		224		220		261		124		186		183		230		259	
Itoplectis 4-cingulatus		0.9		0.8		0.9		1.4		1.9		3.2		2.2		1.6		1.3		2.3
Phaeogenes hariolus		1.3		9.8		0.9		1.4		0		4.0		2.7		8.2		0.9		0
Ephialtes ontario		0.9		0.3		0.4		0.9		0		0		0		0		0.4		0
Agria affinis		1.7		2.2		1.3		6.4		0		0		2.2		1.6		0		0
Ischnus inquisitorius atriceps		0		0		0		0		0		0.8		0		0	2/	0		0
Unknown		2.2		0		0		0		0.8		0		0		1.6		0		0
Combined parasitism		7.0		13.0		3.6		10.0		2.7		8.1		7.0		13.1		2.6		2.3
Aggregate parasitism		38.3		48.2		31.0		51.6		36.0		31.3		55.1		58.9		58.2		35.5

1/ Egg parasitism data are based on whole egg masses and are tabulated for the year of the feeding population.

2/ Unknown hymenopterous parasites attack by chalcids.

Table 4.--Estimates of spruce budworm populations on eight sprayed areas in Oregon and Washington, 1951-54

(Larvae per 100 15-inch twigs)

Location and study area	Year sprayed	Before spraying 1/	After spraying 2/	1951 3/	1952 3/	1953 3/	1954 3/
Cascade Mts.							
Roseburg	1950	840	10	3	(4/)	1	1
Eugene	1949	1350	30	(4/)	1	5	20
McKenzie	1950	480	10	2	8	0	1
Mt. Hood	1949	1030	20	61	180	1	1
Blue Mts.							
So. Umatilla	1950	670	5	5	(4/)	3	8
Catherine Cr.	1950	870	5	15	19	18	11
Walla Walla	1950	500	10	12	33	1	2
Tollgate	1950	690	10	5	4	0	0

1/ Larval populations before spraying are based on samples of predominantly V stage larvae.

2/ Populations after spraying are based on VI stage larvae and pupae.

3/ Populations for 1951-1954 are based on III and IV stage larvae.

4/ Less than 1 larva per 100 twigs.

Table 5.--Parasitism of immature spruce budworm larvae on eight sprayed areas in Oregon and Washington, 1951-54

Location and study area	1951		1952		1953		1954	
	Number of budworm	Parasitism	Number of budworm	Parasitism	Number of budworm	Parasitism	Number of budworm	Parasitism
		Percent		Percent		Percent		Percent
Cascade Mts.								
Roseburg	24	38	1	0	2	0	1	0
Eugene	8	25	6	17	26	12	71	15
McKenzie	7	29	7	14	0	-	1	0
Mt. Hood	175	33	152	32	3	0	2	0
Subtotal	214	33	166	32	31	10	75	15
Blue Mts.								
So. Umatilla	44	59	1	100	9	44	25	20
Catherine Cr.	137	41	55	33	50	42	24	29
Walla Walla	37	51	27	30	1	0	1	0
Tollgate	15	67	3	67	0	-	0	-
Subtotal	233	48	86	34	60	42	50	24
Total	447	41	252	33	91	31	125	18

Table 6.--Estimates of spruce budworm populations on twenty plots in eight sprayed areas in Oregon and Washington, 1953-54

(Immature larvae per 100 15-inch twigs)

Location area and study plot	1953			1954		
	Number of twigs	Number of budworm	Budworm per 100 twigs	Number of twigs	Number of budworm	Budworm per 100 twigs
Cascade Mts.						
Roseburg						
Henry Mill	100	2	2.0	100	0	0
S & S Mill	90	0	0	50	0	0
Clover Creek	50	0	0	50	1	2.0
Eugene						
Creswell	90	2	2.2	85	21	24.7
Sodaville	100	9	9.0	100	26	26.0
Seavay Ranch	100	4	4.0	100	22	22.0
Kampfer Ranch	100	11	11.0	100	24	24.0
Oakridge	100	0	0	90	1	1.1
McKenzie Bridge						
Frissel Cross.	100	0	0	100	1	1.0
Mt. Hood						
Wamic	100	1	1.0	100	0	0
Bear Springs	100	1	1.0	100	0	0
Beaver Butte	100	1	1.0	100	2	2.0
Blue Mts.						
So. Umatilla						
Nigger Nob	100	4	4.0	100	6	6.0
Madison Butte	100	6	6.0	100	14	14.0
Red Hill L.O.	100	0	0	100	5	5.0
Catherine Creek						
Bald Mt. Rd.	100	25	25.0	100	25	25.0
Lt. Catherine Cr.	100	5	5.0	100	0	0
Reeves Mnt.	100	23	23.0	100	8	8.0
Walla Walla						
Baby Springs	100	1	1.0	100	2	2.0
Tollgate						
Langdon Lake	100	0	0	100	0	0

Table 7.--Parasitism of immature spruce budworm larvae on twenty sprayed study plots in Oregon and Washington, 1953

Location area and study plot	Number of budworm	Parasite species				Total parasitism
		Apanteles	Glypta	Horogenes	Unknown	
		Percent				
Cascade Mts.						
Henry Mill	2					0
S & S Mill	0					-
Clover Creek	0					-
Creswell	2					0
Sodaville	9		11			11
Seavay Ranch	4					0
Kampfer Ranch	11		9	9		18
Oakridge	0					-
Frissel Crossing	0					-
Wamic	1					0
Bear Springs	1					0
Beaver Butte	1					0
Subtotal	31		6	3		10
Blue Mts.						
Nigger Nob	4		25			25
Madison Butte	5	20	40			60
Red Hill L.O.	0					-
Bald Mnt.	24	29	8	4		42
Lt. Catherine Cr.	4	25			25	50
Reeves Mnt.	22	23	18			41
Baby Springs	1					0
Langdon Lake	0					-
Subtotal	60	23	15	2	2	42
Total	91	15	12	2	1	31

Table 8.--Parasitism of immature spruce budworm larvae on twenty sprayed study plots in Oregon and Washington, 1954

Location area and study plot	Number of budworm	Parasite species: Apanteles	Glypta	Horogenes	Total parasitism
		Percent			
Cascade Mts.					
Henry Mill	0				-
S & S Mill	0				-
Clover Creek	1				0
Creswell	18	6	6	11	22
Sodaville	20	5	15	5	25
Seavay Ranch	17			6	6
Kampfer Ranch	15		7		7
Oakridge	1				0
Frissel Crossing	1				0
Wamic	0				-
Bear Springs	0				-
Beaver Butte	2				0
Subtotal	75	3	7	5	15
Blue Mts.					
Nigger Nob	6	17	17		33
Madison Butte	14	21			21
Red Hill L.O.	5				0
Bald Mnt.	17	12	12	6	29
Lt.Catherine Cr.	0				-
Reeves Mnt.	7	14	14		29
Baby Springs	1				0
Langdon Lake	0				-
Subtotal	50	14	8	2	24
Total	125	7	7	4	18